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EXPERIMENTS WITH RAILWAY CROSS-TIES.

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INTRODUCTION.

Cheap stumpage is becoming so scarce in the United States that the railways are finding it more and more difficult to secure their tie supplies.

The various conditions which influence the supply of ties, together with the differences in the durability of similar timber laid in different localities, make it impossible to offer a solution of the tie problem which will apply to the entire country.

Previous investigations by the Forest Service have determined that seasoned timber not only lasts longer than green wood when in contact with the soil, but also that it is more receptive of preservative solutions. The rate of seasoning and ability to absorb preservatives varies with different species, and, moreover, the specific gravity of green wood varies with the season of cutting, being greater in winter and spring than in summer.[a] These facts, too, are only of general application. In order to determine the rate of seasoning of different timbers it is necessary to have a definite knowledge of the green weight of each species, and corresponding weights after different periods of seasoning. The length of time which timbers should be seasoned to secure the best absorption of preservative and greatest durability will depend upon the corresponding decrease in the cost of maintenance.

SCOPE AND PURPOSE OF THE STUDY.

The Forest Service entered into a cooperative agreement with the Northern Pacific Railroad to investigate the tie timber accessible to its line, in order to determine the best and most economical methods of handling these timbers when manufactured into cross-ties. The timbers used in the experiment were Douglas fir, western hemlock, western tamarack (western larch), and giant arborvitæ.

The investigation consisted of three separate experiments: First, tests to determine the green weight and rate of seasoning of timbers cut in different months; second, tests to determine the absorptive power of seasoned timbers cut in different months; third, tests to de-

[a] Forest Service Circular 136, Seasoning and Preservative Treatment of Arborvitæ Poles.

termine the comparative durability of green, seasoned, and treated timbers when laid under similar conditions and with various tie-plates and rail fastenings, in a test track.

Two stations were established for conducting the seasoning tests—at Tacoma, Wash., and Sandpoint, Idaho. A substation to the Tacoma experiment was placed at Pasco, Wash. Half of the ties cut each month at Tacoma were shipped to Pasco to compare the rate of seasoning in the two places, which differ widely in climate. The average of these stations gives the average rate of seasoning of Douglas fir for all conditions to be encountered in the Northwest.

Two separate test tracks were constructed, one on the west slope of the Cascade Mountains, near Maywood, Wash., and one in western Montana, near Plains.

CONCLUSIONS REACHED BY THE STUDY.

The final conclusions will be obtained from the test tracks, but those from seasoning and treating are as follows:

(1) There is practically no difference in the rate of seasoning of 7 by 2 and 8 by 1 forms of piles.[a] The rate of seasoning, as affected by the position of the pile, depends largely upon local conditions.

(2) Hewed ties, which are peeled when cut, season much more rapidly during the first four months than unpeeled ties. At the end of a year's seasoning, however, the weights of both peeled and unpeeled ties are approximately uniform.

(3) The oven-dry weight of Douglas fir is 28.3 pounds per cubic foot. The green weight varied from 41.7 pounds in February to 37 pounds in July. The minimum air-seasoned weight reached was 31.9 pounds per cubic foot.

(4) Two distinct forms of checks occur on Douglas fir—radial and honeycomb. Timbers cut in June, July, and August are particularly subject to radial checking. Honeycomb checks both follow the curves of the annual rings and are at right angles to them; they seldom extend more than 2 inches on the radius and form small, roughly rectangular figures when seen in cross section.

Radial checks are by far the most destructive, and the practice of cutting tie and bridge timbers from Douglas fir and western hemlock during June, July, August, and September should be discontinued. Furthermore, at all seasons dimension material over 6 by 6 inches should be partially air seasoned before being shipped east of the Cascade Mountains.

(5) Hewed ties peeled directly before treatment absorb more preservative than those peeled when cut, provided they have seasoned for an equal length of time.

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[a] For forms of piling ties see Forest Service Circular 132, The Seasoning and Preservative Treatment of Hemlock and Tamarack Cross-Ties.

FACTORS WHICH DETERMINE THE LIFE OF CROSS-TIES.

Tie failures, in general, are due to decay and mechanical abrasion.

DECAY.

The rate at which cross-ties decay depends upon a number of factors, among the most important of which are general climatic conditions, such as the amount of precipitation and of humidity, and the intensity of heat; the drainage of the roadbed, which depends largely upon the ballast, and the protection from mechanical abrasion furnished by tie plates and improved rail fastenings.

The climatic conditions of the territory through which the Northern Pacific passes show great variation in regard to both temperature and rainfall. The total annual rainfall varies from 7 inches in some places to 95 in others, and temperatures from 50° below to 115° above zero, Fahrenheit. Because of these varying conditions many forms of wood-destroying fungi are to be found, and they make the problem of maintenance extremely difficult. The most destructive forms of fungi observed were *Merulius lacrymans* and *Polyporus betulinus.*

MECHANICAL ABRASION.

Mechanical abrasion may result from two actions of the rail, each independent of the other. These are called rail cutting and rail sawing. Rail fastenings perform two functions; they hold the rail perpendicular to the tie, and prevent lateral spreading. Experience has proved that the present rail fastenings, cut spikes, are fairly satisfactory when used with hardwood ties, but they are by no means adapted for use with softwood ties. In order to protect the softer woods, tie plates have been introduced. These plates not only protect the ties, but materially assist the spikes in overcoming the lateral force which tends to spread the rails, and therefore take the place of rail braces.

There are many different designs of tie plates in use, but all can be classified under two general forms—those with downward projections which penetrate the wood fibers, and those with flat under surfaces. The relative merits of the two forms are here considered only with regard to their effect in prolonging the life of the tie.

SEASONING EXPERIMENTS AT TACOMA AND PASCO.

CHARACTER OF THE TIMBER.

Douglas fir was used exclusively in the seasoning experiments at Tacoma and Pasco. The ties were sawed from logs ranging from 3 to 6 feet in diameter. The wood showed from 4 to 36 rings per radial inch. The sapwood of Douglas fir seldom exceeds 3 inches. Owing

to this fact and the custom of sawing ties from coarse heartwood timber, the seasoning experiments on Douglar fir show a small loss of moisture in per cent of green weight as compared with other species.

Four hundred ties were cut each month of the year from November, 1903, to December, 1904, except that in September, 1904, none were cut. Of these, 200 ties were marked, weighed, and shipped each month to Pasco. A new series was started at Tacoma in December, 1904, and continued until July, 1905, to act as a check on the first series through the rainy season. As a rule, the ties were weighed within three and one-half days from the time the trees were felled; hence the first weight is the approximate green weight.

A 7 by 2 pile was adopted at both Tacoma and Pasco, with 50 ties in each pile. Two piles of each series of 200 ties were faced north and south and two piles east and west.

A monthly meteorological table (Table 1), prepared by the United States Weather Bureau station at Tacoma, was used to show whether the ties seasoned under normal conditions and to determine what effect climatic changes had upon the amount and rate of seasoning. No such data were obtainable at Pasco.

TABLE 1.—*Meteorological conditions at Tacoma, Wash.*

Month.	Rainfall.			Average monthly rainfall based on 12 years.	Direction of wind and velocity per hour.					
					Direction.			Velocity.		
	1903.	1904.	1905.		1903.	1904.	1905.	1903.	1904.	1905.
	Inches.	*Inches.*	*Inches.*	*Inches.*				*Miles.*	*Miles.*	*Miles.*
January	.....	6.39	4.93	6.39	.....	SW.	SW.	.....	7.1	4.9
February	.....	7.57	2.51	5.35	.....	SW.	N.	.....	8.1	5.9
March	.....	6.08	3.78	3.93	.....	SW.	N.	.....	8.3	6.5
April	.....	3.84	0.71	3.48	.....	SW.	N.	.....	5.8	6.1
May	.....	1.04	4.15	2.51	.....	N.	SW.	.....	5.8	6.7
June	.....	1.36	3.23	1.78	.....	N.	SW.	.....	6.3	5.2
July	.....	0.94	0.34	0.78	.....	N.	N.	.....	6.1	4.8
August	.....	0.07	0.39	0.73	.....	N.	N.	.....	4.1	5.4
September	.....	0.04	2.79	2.18	.....	N.	SW.	.....	4.0	5.9
October	2.72	1.27	5.50	4.00	N.	N.	N.	5.1	4.5	5.8
November	10.00	11.88	3.08	6.11	SW.	SW.	SW.	6.2	5.9	4.5
December	4.51	5.07	5.19	7.39	SW.	SW.	SW.	4.2	6.6	5.7
Total	.....	45.91	36.60	[a] 44.63	.....	.....	.....	.....	.....	.....

[a] Annual average.

GREEN AND SEASONED WEIGHTS.

The green weight of Douglas fir, based on the data obtained from 4,000 ties seasoned at Tacoma, shows a seasonal variation of 4.7 pounds per cubic foot. The timber weighed 37 pounds per cubic foot in July and 41.7 pounds in February and March. A thousand feet, board measure, of the July timbers weighed 3,082 pounds, of the February and March timbers 3,474 pounds. The yearly average was 3,284 pounds per thousand feet. These results correspond very

closely to the rough green weight of 3,300 pounds adopted by the lumber associations in the Northwest.

Table 2 shows the green and seasoned weight per cubic foot and per thousand feet, board measure, of Douglas fir. The seasoned weight is based on eleven months' seasoning. The column on the right gives the time required for the various months' cuts to reach their minimum weight.

TABLE 2.—*Green and seasoned weight of Douglas fir, Tacoma, Wash., based on eleven months' seasoning.*[a]

Month cut.	Weight per cubic foot.		Weight per M board feet.		Seasoning period to reach minimum weight.
	Green.	Dry.	Green.	Dry.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Months.*
January	39.7	33.4	3,307	2,782	7
February	41.7	34.9	3,474	2,907	6
March	41.7	35.4	3,474	2,949	5
April	39.4	34.0	3,282	2,832	4
May	39.0	35.1	3,228	2,924	4
June	38.3	34.3	3,190	2,857	3
July	37.0	33.1	3,082	2,757	10
August	39.4	34.9	3,282	2,907	11
September	39.0	34.0	3,230	2,832	11
October	38.5	33.1	3,207	2,757	10
November	40.2	34.4	3,349	2,866	9
December	39.6	33.4	3,299	2,782	8
Average	39.5	34.2	3,284	2,854	7.3

[a] Compare time required to reach minimum weight with the amount of rainfall during that time in meteorological table.

The oven-dry weight is 28.3 pounds per cubic foot.

POSITION OF THE PILE WITH REGARD TO WIND DIRECTION.

The seasoning experiments at Tacoma and Pasco showed that there is little difference in the rate of seasoning of timbers stacked in piles which face different directions. The greatest difference for any single month was 2 per cent, while the average difference for a year's cut, based on eleven months' seasoning, was 0.05 per cent at Tacoma and 0.02 at Pasco.

In view of the slight difference between the two forms of piles, the results at both Tacoma and Pasco have been based on a total of 200 ties for each month.

RATE OF SEASONING.

The oven-dry[a] weight of Douglas fir used as a basis in this experiment was taken from data established by Professor Hunt at Berkeley, Cal. His results show a variation from 22.1 to 36.2 pounds per cubic

[a] The weight determined by drying small pieces of the wood in an oven at 100° C. until a constant weight is obtained. For further discussion of this see Forest Service Circular 115, Second Progress Report on the Strength of Structural Timber.

foot. The average for all grades, 28.3 pounds per cubic foot, was taken as the basis.

The standard dimensions of sawed ties are 7 by 9 inches by 8 feet, and therefore each tie contains 3.5 cubic feet. Several hundred of the experimental ties were carefully measured and found to conform with the specifications; hence, the weight of each tie was divided by 3.5, the number of cubic feet it contained, and all results expressed in weight per cubic foot.

The results given in Tables 3 and 4 furnish a comparison of the maximum and minimum rates of seasoning of Douglas fir under two entirely different climatic conditions. While the weight per cubic foot and moisture content of the green timber seasoned at each station was practically the same, there is a wide difference in the rate of seasoning. On account of the uniform rate of seasoning of certain months' cuts at Pasco, it has been possible to make four groups and thereby simplify the results. The following four groups were therefore made: (1) October, November, December, and January; (2) February, March, April, and May; (3) June and July; (4) August and September.[a] It is impossible to group the monthly cuts at Tacoma.

TABLE 3.—*Rate of seasoning of Douglas fir ties, Pasco, Wash.*

Time Seasoned (days).	October, November, December, January.		February, March, April, May.		June and July.		August.	
	Moisture content in per cent of dry weight.[b]	Weight per cubic foot.	Moisture content in per cent of dry weight.	Weight per cubic foot.	Moisture content in per cent of dry weight.	Weight per cubic foot.	Moisture content in per cent of dry weight.	Weight per cubic foot.
	Per cent.	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*
0	39.9	39.6	41.9	40.2	35.4	38.3	39.3	39.4
30	33.7	37.8	20.9	36.8	23.9	35.1	29.0	36.5
60	31.4	37.2	24.3	35.2	20.0	34.0	26.1	35.7
90	29.5	36.7	20.8	34.2	18.0	33.4	26.0	35.7
120	26.1	35.7	18.5	33.6	18.4	33.5	26.0	35.7
150	22.7	34.7	16.8	33.1	19.2	33.7	26.0	35.7
180	20.8	34.2	16.2	32.9	19.6	33.9	25.9	35.6
210	18.8	33.6	16.9	33.1	19.7	33.9	24.0	35.1
240	16.9	33.1	17.7	33.3	19.4	33.8	22.5	34.7
270	15.3	32.6	18.2	33.5	18.5	33.6	21.1	34.3
300	15.4	32.7	18.4	33.5	17.5	33.3	19.3	33.8
330	16.2	32.9	18.1	33.4	16.3	32.9	16.9	33.1

[a] No cut was received during September, but the results would undoubtedly correspond with those of August.

[b] Oven-dry weight is 28.3 pounds per cubic foot.

TABLE 4.—*Rate of seasoning of Douglas fir ties, Tacoma, Wash.*

MOISTURE CONTENT IN PER CENT OF DRY WEIGHT.[a]

Time seasoned (days).	Month cut.										
	January.	February.	March.	April.	May.	June.	July.	August.	October.	November.	December.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
0	40.3	47.3	49.5	38.3	40.3	33.2	28.3	39.0	34.3	42.5	39.2
30	41.0	41.0	39.0	29.6	30.0	25.2	20.0	31.5	35.4	41.4	39.4
60	35.9	35.7	33.4	23.5	26.1	22.5	18.0	31.0	34.8	39.7	41.0
90	31.0	31.0	29.3	21.0	24.6	21.4	19.0	34.5	32.9	37.4	36.0
120	26.2	26.9	26.5	20.1	24.0	21.2	23.0	36.4	30.7	34.0	31.2
150	22.0	24.2	25.1	19.9	25.2	27.0	25.0	35.9	28.4	30.7	26.6
180	19.3	23.4	25.0	20.2	29.4	29.2	24.6	34.1	26.0	28.3	22.5
210	17.8	23.2	25.9	23.0	31.0	28.9	23.0	32.0	23.8	26.5	19.6
240	17.6	23.6	30.0	25.8	30.7	27.8	20.8	29.8	21.5	24.7	18.0
270	19.1	26.4	32.0	25.6	30.0	26.0	18.7	27.7	19.5	22.7	18.0
300	21.8	29.7	31.7	24.5	29.1	23.9	17.2	25.8	17.5	25.3	19.2
330	24.5	30.0	29.7	23.4	25.8	21.5	16.4	23.9	19.8	25.3	22.9

WEIGHT PER CUBIC FOOT.

	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
0	39.7	41.7	42.3	39.1	39.7	37.7	36.3	39.3	38.0	40.3	39.4
30	39.9	39.9	39.3	36.7	36.8	35.4	34.0	37.2	38.3	40.0	39.5
60	38.5	38.4	37.8	35.0	35.7	34.7	33.4	37.1	38.1	39.5	39.9
90	37.1	37.1	36.6	34.2	35.3	34.4	33.7	38.1	37.6	38.9	38.5
120	35.7	35.9	35.8	34.0	35.1	34.3	34.8	38.6	37.0	37.9	37.1
150	34.5	35.1	35.4	33.9	35.4	35.9	35.4	38.5	36.3	37.0	35.8
180	33.8	34.9	35.4	34.0	36.6	36.6	35.3	38.0	35.7	36.3	34.7
210	33.3	34.9	35.6	34.8	37.1	36.5	34.8	37.4	35.0	35.8	33.8
240	33.3	35.0	36.8	35.6	37.0	36.2	34.2	36.7	34.4	35.3	33.4
270	33.7	35.8	37.4	35.5	36.8	35.7	33.6	36.1	33.8	34.7	33.4
300	34.5	36.7	37.3	35.2	36.5	35.1	33.2	35.6	33.3	35.5	33.7
330	35.2	36.8	36.7	34.9	35.6	34.4	32.9	35.1	33.9	35.5	34.8

[a] Oven-dry weight is 28.3 pounds per cubic foot.

Three important conclusions may be drawn from seasoning timbers under different climatic conditions: (1) Timbers cut during different months will eventually reach approximately the same weight per cubic foot in regions with a minimum rainfall; but in humid climates the maximum loss in weight corresponds closely to the seasonal variation in the green weight. These results failed to substantiate the theory that the varying physical characteristics of timber cut at different seasons determine the minimum air-seasoned weight. (2) Rainfall is the chief factor in determining the rate of seasoning. (3) The rate of seasoning determines, to a great extent, the resultant behavior of the timber as to checking.

CHECKING.

In order to determine the effect of the rate of seasoning upon the condition of the timber, frequent photographs were taken of each month's cut. Two kinds of checks were observed—radial and small honeycomb. Honeycomb checks occur on timbers which season slowly during the first few months. Radial checks occur on timbers

which season rapidly during the first few months, that is, timbers which are cut during the period from June to September. A study of these two forms of checks indicates that honeycomb checks cause little damage to the tie, while radial checks are very destructive and often make the tie unfit for service. Because of the excessive checking of Douglas fir, many eastern concerns will not use this timber in large dimensions. In view of these seasoning experiments, it is believed that this objection can be eliminated and the market of Douglas fir extended. Cutting should be limited to the months from November

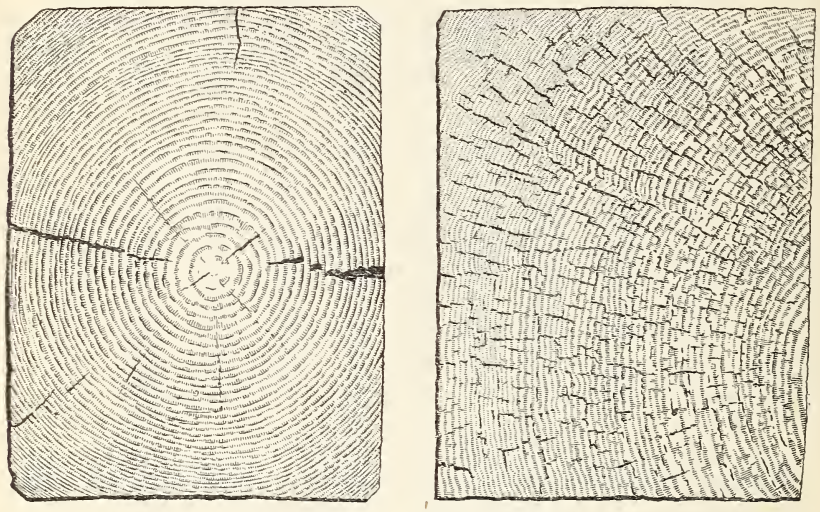


FIG. 1.—Radial and honeycomb checks.

to April, inclusive, and the timber seasoned for at least ninety days before being shipped through the arid region east of the Cascade Mountains.

TREATMENT OF TEST TIES (CREOSOTE).

Four hundred and fifty of the ties seasoned at Tacoma were selected for treatment. These were treated by the straight creosote method. After treatment the ties were again seasoned four months before being placed in the track.

In order to determine the absorption by increase in weight the ties were weighed before and after treatment, then ninety days later. The increase in weight during treatment was 8.6 pounds per cubic foot. After ninety days seasoning an average of 2.4 pounds of this increase had been lost, leaving the net increase per cubic foot 6.2 pounds. When the ties were placed in the track they contained an average of about 6 pounds of creosote per cubic foot.

Table 5 gives the average increase in weight per tie for each month's cut

TABLE 5.—*Seasoned Douglas fir ties—amount of creosote absorbed per tie for different months' cuts as shown by weight before treatment and three months after treatment.*

Month.	Pounds.	Month.	Pounds.
January	21.30	August	22.92
February	19.71	September	
March	15.89	October	21.18
April	21.93	November	21.94
May	23.89	December	23.86
June	21.29		
July	23.66	Average	[a] 21.59

[a] Or 6.17 pounds per cubic foot.

SEASONING EXPERIMENTS AT SANDPOINT (IDAHO TIMBERS).

The timbers used in the Idaho experiment were Douglas fir, western tamarack, and giant arborvitæ.[a] The Douglas fir of Idaho and Montana differs greatly from that of the Pacific slope, as it seldom reaches 3 feet in diameter. From stem analysis it was found that the age of the Douglas fir from which the ties were cut varied from 96 to 151 years and of the tamarack ties from 100 to 205 years. The ties were generally hewed and varied much in size and shape. In consequence of this it was impossible to determine their volume accurately; therefore the seasoning results are expressed in per cent of the first or green weight of the ties.

Meteorological data were not available, but with the exception of October, 1905, when heavy rains occurred just before the weighings, the seasoning took place under normal conditions.

From September, 1904, to April, 1905, a total of 2,350 ties were cut; divided nearly equally between the fir and tamarack. As a rule, 200 ties of each species were cut each month; of this number, 50 ties were peeled and piled to correspond in form and position with a pile of unpeeled ties.

FORM OF PILES.

Three forms of piles were used—7 by 2, 8 by 1, and solid. The effect of the form of pile upon the rate of seasoning is given in Table 6. As a rule, the 7 by 2 piles showed a greater loss than the 8 by 1 piles, though the average difference was very small. The solid piles seasoned much slower than the open piles during the first few months, but their minimum weight gradually approached that of the open piles, and were about equal after twelve months' seasoning.

[a] Only two months' cuts of giant arborvitæ were received. On account of the unimportance of this timber for cross-ties, the results have been omitted from this report.

TABLE 6.—*Comparative rate of seasoning of 7 by 2 and 8 by 1 piles, based on the loss per cent of the green weight.*

Date cut.	Maximum loss.	
	Pile 7 by 2.	Pile 8 by 1.
	Per cent.	*Per cent.*
November 1	17.14	12.79
November 16	20.81	20.00
December 15	22.50	21.72
January 16	18.45	18.31

PEELING.

The peeling of timbers was found to be the most important factor in determining the rate of seasoning. Since the unpeeled ties, piled in different forms, seasoned at approximately the same rate, the results of each form have been averaged. (Tables 7 and 8.) The results, therefore, give a comparison of the rate of seasoning of peeled and unpeeled ties for both Douglas fir and western tamarack. They indicate that peeled Douglas fir ties, cut during November, December, and January, will have seasoned sufficiently for treatment by the following May, whereas unpeeled ties of the same months' cuts do not reach as low a moisture content until from three to five months later. The same general conclusions are applicable to western tamarack, except that its rate of seasoning is much slower and, because of its thin bark, the difference between the peeled and unpeeled ties is less marked.

TABLE 7.—*Loss of first weight of peeled and unpeeled ties through seasoning, Douglas fir, Sandpoint, Idaho.*

Time weighed.	Total loss, per cent of first weight.											
	September cut.		November cut (1).		November cut (2).		December cut.		January cut.		April cut.	
	Unpeeled.	Peeled.	Unpeeled.	Peeled.	Unpeeled.	Peeled.	Unpeeled.	Peeled.	Unpeeled.	Peeled.	Unpeeled.	Peeled.
1904.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
October	3.25	9.36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
November	6.89	11.11	0.57	1.69	.....	.....	.....	.....	.....	.....	.....	.....
December	6.89	11.11	.....	3.93	0.35	2.69	.....	.....	.....	.....	.....	.....
1905.												
January	6.92	11.70	.20	5.62	1.05	4.30	0.87	1.09	.....	.....	.....	.....
February	7.73	11.70	.39	8.43	2.10	7.53	1.89	3.28	0.81	1.04	....	.....
March	8.81	12.87	2.49	12.36	3.85	11.29	3.94	7.10	2.92	5.73	.....	.....
April	10.47	14.62	4.01	16.29	6.13	16.13	6.69	13.11	5.70	11.98	.....	.....
May	12.65	15.20	6.29	18.54	9.95	20.43	10.81	18.03	9.96	17.71	6.19	12.57
June	14.86	16.96	9.54	20.22	14.16	22.04	15.25	20.22	14.86	19.27	11.00	16.77
July	16.27	18.13	11.25	21.35	16.75	23.12	17.81	21.86	17.15	20.31	13.68	17.37
August	17.86	[a]19.88	14.11	[a]22.47	19.75	25.27	20.18	[a]23.50	20.09	[a]22.40	16.37	[a]19.76
September	[a]18.94	19.88	[a]15.25	22.47	[a]21.14	[a]25.81	[a]21.57	23.50	[a]21.07	22.40	[a]17.72	19.76
October	17.04	17.54	13.15	20.79	20.25	23.66	20.71	21.31	20.26	20.83	15.83	17.96
November	17.62	16.96	13.54	20.79	20.08	23.12	21.22	22.40	20.91	21.35	16 64	18.56
Average first weight of tie, in pounds	[b] 1.82	[b] 1.71	[c] 1.75	[c] 1.78	[d] 1.91	[d] 1.86	[e] 1.95	[e] 1.83	[f] 2.04	[f] 1.92	[g] 1.87	[g] 1.69

[a] Maximum per cent lost.
[b] September 21.
[c] November 2.
[d] November 17.
[e] December 16.
[f] January 16.
[g] April 20.

TABLE 8.—*Loss of first weight of peeled and unpeeled ties through seasoning, western tamarack, Sandpoint, Idaho.*

Time weighed.	Loss of weight.											
	October cut.		November cut (1).		November cut (2).		December cut.		January cut.		April cut.	
	Unpeeled.	Peeled.	Unpeeled.	Peeled.	Unpeeled.	Peeled.	Unpeeled.	Peeled.	Unpeeled.	Peeled.	Unpeeled.	Peeled.
1904.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
October	0.48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
November	.73	1.09	0.52	2.37	.....	.....	.....	.....	.....	.....	.....	.....
December	.73	1.09	.85	3.79	0.74	1.88	.....	.....	.....	.....	.....	.....
1905.												
January	.97	1.09	1.03	5.69	.98	2.82	0.65	3.21	.....	.....	.....	.....
February	1.20	1.63	2.23	7.11	2.44	4.69	1.78	5.50	0.64	1.82	.....	.....
March	2.64	2.72	3.42	9.00	4.38	7.98	4.21	6.88	2.81	4.55	.....	.....
April	4.08	4.89	4.96	11.37	6.58	12.68	7.12	11.47	5.28	10.00	.....	.....
May	6.25	6.52	7.53	13.27	9.98	15.96	11.00	15.14	8.82	13.64	5.38	9.33
June	8.40	8.70	10.09	15.17	13.14	18.78	14.88	17.89	12.08	16.36	9.75	13.99
July	10.08	9.78	11.98	16.59	14.85	20.19	17.30	19.72	14.58	17.73	12.30	15.03
August	12.71	11.96	14.36	[a]18.96	18.74	22.07	20.53	22.02	17.20	[a]19.55	15.12	18.13
September	[a]13.43	[a]13.04	[a]15.56	18.96	[a]19.96	[a]22.54	[a]21.99	[a]22.94	[a]18.27	19.55	[a]16.41	[a]18.65
October	12.23	10.87	14.02	18.48	18.74	21.13	20.85	21.10	17.50	19.09	15.38	17.62
November	12.23	10.87	14.01	18.84	18.74	20.66	21.17	21.10	18.27	19.55	16.41	16.58
Average first weight of tie in pounds	[b]208.5	[b]1.84	[c]1.95	[c]2.11	[d]2.06	[d]2.13	[e]2.06	[e]2.13	[f]2.15	[f]2.20	[g]1.95	[g]1.93

[a] Maximum per cent lost.
[b] October 6.
[c] November 1.
[d] November 18.
[e] December 15.
[f] January 16.
[g] April 20.

In view of these results the peeling of all ties as soon as cut is highly recommended. Not only is there greater rapidity of seasoning, but the peeled ties are more uniform in shape and so permit a greater number to be shipped per carload. From Tables 7 and 8 it would not seem profitable to air-season the ties completely if they are to be treated. However, if the timbers are to be used untreated the greatest durability will be secured by continuing the seasoning until the most complete air-seasoned condition has been reached.

Table 9 shows approximately the length of time required to get the timbers of different months' cuts in the best possible condition for treatment.

TABLE 9.—*Probable seasoning period of peeled and unpeeled ties.*

Month cut.	Month when ties will have seasoned sufficiently for treatment.			
	Douglas fir.		Western tamarack.	
	If peeled.	If unpeeled.	If peeled.	If unpeeled.
September	April	June	June	July.
October	April	September	June	September.
November	May	September	June	September.
December	May	September	July	September.
January	June	September	August	September.
February	July	September	August	September.
March	July	September	August	September.
April	July	September	August	September.

The peeling of ties as soon as cut allows more seasoning during the first few months, when ties are usually shipped and therefore means a saving in freight. To determine this a number of ties were weighed before and after they were peeled and compared with unpeeled ties. At the end of six months the peeled ties lost 34 pounds more than the unpeeled; of this loss, 15 pounds was the weight of the bark. The average volume of these ties was about 4 cubic feet. The average loss of weight of the peeled ties was 9.5 pounds per cubic foot as compared with a loss of 4.75 pounds per cubic foot of the unpeeled ties.

TREATMENT OF TEST TIES (ZINC CHLORID).

From the different months' cuts seasoned at Sandpoint the following kinds and numbers of ties were treated with zinc chlorid, a 6 per cent solution being used. An estimate by the gauge readings showed an injection of 0.786 pound of pure chlorid per cubic foot of timber.

	Douglas fir ties.	Western tamarack ties.
Unpeeled	105	115
Peeled	80	100

Both species were treated in the same charge, yet as a rule the tamarack ties show a better impregnation than the Douglas fir, as follows:

	Increase in weight per tie.	
	Douglas fir.	Tamarack.
	Pounds.	*Pounds.*
Peeled when cut	36.3	51.02
Peeled directly before treatment	40.2	51.00

These figures show not only the comparative rate of absorption of both species treated under the same conditions, but also that the Douglas fir ties peeled directly before treatment were more susceptible to preservatives than those peeled when cut. These results are contrary to general expectations, since the ties peeled when cut had reached a slightly lower moisture content than those peeled directly before treatment.

TEST TRACK AT MAYWOOD, WASH.

NATURE OF TRACK.

The ties for this test were placed in the main line of the Northern Pacific Railway, about 6 miles west of Hot Springs, Wash., near the station of Maywood. They were laid in a continuous stretch, extending from 2,410 feet west of milepost 197 (Pasco–Tacoma) to about 1,185 feet west of milepost 198, covering approximately 4,055 feet

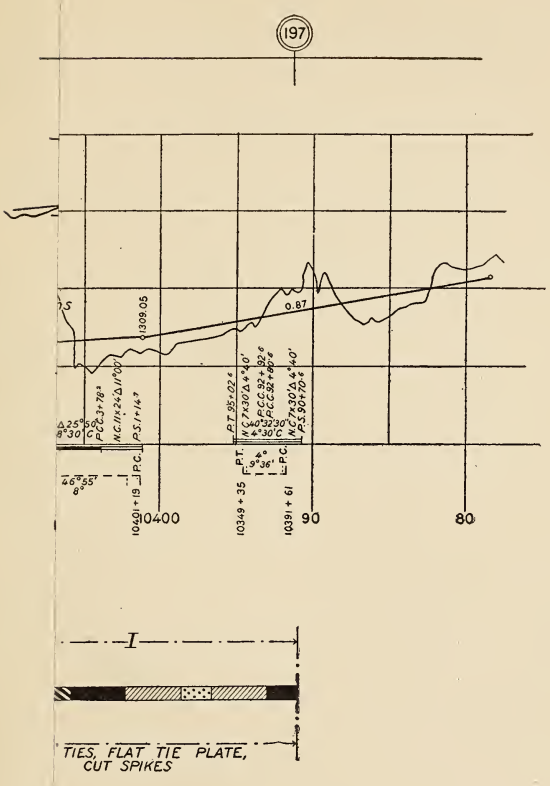
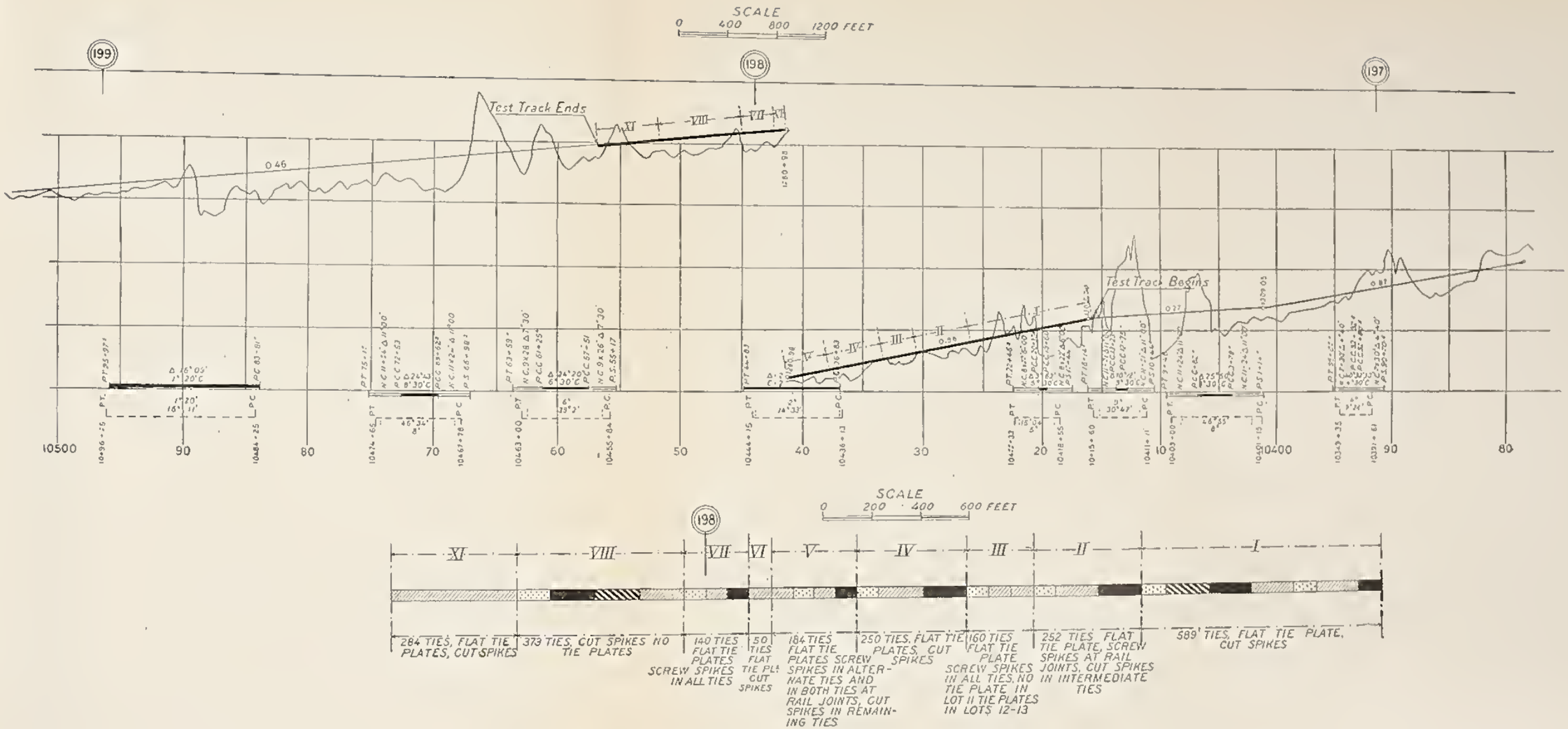


FIG. eet west of milepost 198; all track laid with 85-pound steel.



MATERIAL USED

- Green Douglas Fir Ties
- Seasoned Douglas Fir Ties
- Treated Douglas Fir Ties (Creosoted)
- Green Hemlock Ties

FIG. 2.—Northern Pacific Railway test track, 1⅛ miles west of Maywood, Wash. on main line, Pacific Division. Test track begins 2,400 feet west of milepost 197 and extends to 1,193 feet west of milepost 198; all track laid with 85-pound steel.

of track or about three-quarters of a mile. Two curves, one of 2° and the other of 5°, are included in this section. The grade varies from 0.46 to 0.96 per cent, as shown in figure 2. The following material was used:

Green western hemlock ties	203
Green Douglas fir ties	557
Seasoned Douglas fir ties	1,078
Seasoned and creosoted Douglas fir ties	442
Total ties	2,280
Screw spikes	1,500
Flat tie plates	3,700

FLAT PLATES; SCREW SPIKES AND CUT SPIKES.

The flat plates, used exclusively in this test, measure $6\frac{3}{16}$ by $8\frac{7}{8}$ inches, giving a bearing surface on the tie of 54.9 square inches. Wherever tie plates were used with screw spikes it was necessary to enlarge the holes in the tie plates to a diameter of $\frac{15}{16}$ inch. The screw spikes were imported from France, and are similar to those used by the French Eastern Railway. The spikes have the following dimensions: Total length, 6.39 inches; length exclusive of head, 5 inches; diameter, 0.92 inch; diameter of core, 0.66 inch. There are 9 spirals with a pitch of thread of 0.49 inch and a height of thread of 0.13 inch. The spikes weighed 1.16 pounds each. The common track spikes used are 5.5 inches long, exclusive of the head, and measure $\frac{9}{16}$ by $\frac{9}{16}$ inch in cross section.

It is the general practice to double spike all ties on the mountain curves; that is, to insert eight spikes per tie, four at each end. This was adhered to throughout the test wherever common spikes were employed. In the case of screw spikes, four were inserted per tie, on both tangents and curves. An $\frac{11}{16}$ auger was used in boring the holes for inserting the screw spikes. The holes were filled with creosote before the spikes were screwed into place.

The roadbed, for the most part, is earth embankment, well drained. Gravel is used exclusively for ballast. The valley, at the point where the track has been placed, is very narrow, with standing timber on both sides of the right of way, so that the track receives the sun only a few hours of the day.

SCHEME OF TESTS.

Nine general series were made for the comparison of different factors. Each series was subdivided into several lots. The purposes of the various divisions and subdivisions of each series are as follows:

Series 1 consists of different kinds of timber under ordinary track conditions; that is, with cut spikes and tie plates. It furnishes a

comparison of timbers and forms a basis upon which comparisons of durability can be made, especially with those series where screw spikes are employed. Series 2, 3, 4, and 7 cover all conditions under which screw spikes might be used. In 3 and 7, screw spikes were used on every tie; that is, four spikes per tie. In series 3, lot 11, no tie plates were used; this was to test the value of screw spikes in preventing rail cutting without the use of tie plates. Series 2 and 5 include a combination of screw and cut spikes; series 2 has screw spikes at rail joints only, and cut spikes on the intermediate ties; series 5 has screw spikes on alternate ties and on both ties at rail joints. The object of these two series was to give a transition from an ideal track with screw spikes and tie plates on every tie to the present standard track conditions where cut spikes and tie plates are employed.

Since the great cost of equipping a large system with screw spikes might prevent such a step for many years, it was thought possible that this expense might be lessened by using a combination of screw and cut spikes, which would increase the durability of the timber at a minimum expense. Moreover, since the holding power of a screw spike is from two to four times that of an ordinary spike,[a] this combination might prevent rail creeping and so prolong the life of timbers on mountain grades.

Series 4, 6, and 8 are a duplication of series 1, with a further comparison as to the value of tie plates. The object in separating these lots was to cover the varying conditions of location, such as are encountered in a cut or on a fill and on tangents or curves.

Series 9 was included to compare the durability of seasoned timbers cut during different seasons of the year. All ties were laid under the same conditions, namely, with cut spikes and tie plates.

Copper burrs were used for marking the ties. The burrs were placed in the face of the tie, 6 inches from the inside of the left rail in the direction from Maywood to Tacoma, and are numbered consecutively from east to west.

Plan of test track of Northern Pacific Railway near Maywood, Wash.

SERIES 1.—589 TIES; COMMON SPIKES; TIE PLATES.

Lot No.	Number of ties.	Kind of timber.	Tie Nos.
1	64	Green Douglas fir	1 to 64
2	100	Seasoned Douglas fir	65 to 164
3	53	Creosoted Douglas fir	165 to 227
4	100	Seasoned Douglas fir	228 to 327
5	100	Green Douglas fir	328 to 427
6	100	Green hemlock	428 to 527
7	60	Creosoted Douglas fir	528 to 587

[a] See Forest Service Circular 46, The Holding Force of Railroad Spikes in Wooden Ties.

Plan of test track of Northern Pacific Railway near Maywood, Wash.—Continued.

SERIES 2.—252 TIES; SCREW SPIKES AT RAIL JOINTS; COMMON SPIKES IN INTERMEDIATE TIES; TIE PLATES.

Lot No.	Number of ties.	Kind of timber.	Tie Nos.
8	100	Green Douglas fir	588 to 687
9	100	Seasoned Douglas fir	688 to 787
10	52	Creosoted Douglas fir	788 to 839

SERIES 3.—160 TIES; SCREW SPIKES IN ALL TIES; NO TIE PLATES IN LOT NO. 11; TIE PLATES IN LOTS NOS. 12 AND 13.

11	58	Seasoned Douglas fir	840 to 897
12	51	....do	898 to 947
13	51	Creosoted Douglas fir	948 to 999

SERIES 4.—250 TIES; COMMON SPIKES; TIE PLATES.

14	100	Green Douglas fir	1,000 to 1,099
15	100	Seasoned Douglas fir	1,100 to 1,199
16	50	Creosoted Douglas fir	1,200 to 1,249

SERIES 5.—184 TIES; SCREW SPIKES IN ALTERNATE TIES AND IN BOTH TIES AT RAIL JOINTS; COMMON SPIKES IN REMAINING TIES; TIE PLATES.

17	47	Green Douglas fir	1,250 to 1,296
18	45	Seasoned Douglas fir	1,297 to 1,341
19	46	Creosoted Douglas fir	1,342 to 1,387
20	46	Seasoned Douglas fir	1,388 to 1,433

SERIES 6.—50 TIES; COMMON SPIKES; TIE PLATES.

21	50	Seasoned Douglas fir	1,434 to 1,483

SERIES 7.—140 TIES; SCREW SPIKES IN ALL TIES; TIE PLATES.

22	46	Green Douglas fir	1,484 to 1,529
23	45	Seasoned Douglas fir	1,530 to 1,574
24	49	Creosoted Douglas fir	1,575 to 1,623

SERIES 8.—373 TIES; COMMON SPIKES; NO TIE PLATES.

25	99	Seasoned Douglas fir	1,624 to 1,722
26	103	Green hemlock	1,723 to 1,825
27	100	Green Douglas fir	1,826 to 1,925
28	71	Creosoted Douglas fir	1,926 to 1,996

SERIES 9.—284 TIES; COMMON SPIKES; TIE PLATES.

29	25	Seasoned Douglas fir (January cut)	1,997 to 2,021
30	25	Seasoned Douglas fir (February cut)	2,022 to 2,046
31	25	Seasoned Douglas fir (March cut)	2,047 to 2,071
32	25	Seasoned Douglas fir (April cut)	2,072 to 2,096
33	25	Seasoned Douglas fir (May cut)	2,097 to 2,121
34	25	Seasoned Douglas fir (June cut)	2,122 to 2,146
35	25	Seasoned Douglas fir (July cut)	2,147 to 2,171
36	36	Seasoned Douglas fir (August cut)	2,172 to 2,207
37	25	Seasoned Douglas fir (October cut)	2,208 to 2,232
38	25	Seasoned Douglas fir (November cut)	2,233 to 2,257
39	23	Seasoned Douglas fir (December cut)	2,258 to 2,280

Total number of ties cut, 2,282.

TEST TRACK NEAR PLAINS, MONT.

NATURE OF TRACK.

The ties for this test were placed on the main line of the Northern Pacific Railway, beginning about 2 miles west of Plains, Mont. The ties were all laid on a tangent in a continuous stretch, extending from 3,461 feet west of milepost 203 (Helena–Hope) to 3,203 feet west of milepost 204, covering approximately 4,800 feet of track, exclusive of space omitted for crossings, switches, and bridges. There is a uniform grade of 0.0167 per cent over the entire test track, as shown by figure 3.

FLAT, FLANGED, AND WOODEN PLATES—SCREW SPIKES.

The material used for this test was as follows:

Ties:

Tamarack—Green, 570; seasoned, 571; treated, 197.
Douglas fir—Green, 551; seasoned, 568; treated, 193.
Total, 2,650.

Tie plates:

Flanged plates	794
Flat plates with ordinary spikes	1,726
Flat plates with screw spikes	1,984
Combination (flat and flanged)	360
Wooden plates	436
Total	5,300

The wooden plates were made of white oak, treated with one-twelfth of a pound of creosote each. The plates had the following dimensions: Length, 7 inches; thickness, $\frac{1}{4}$ inch; and width a little greater than the base of the rail.

The ties were generally spaced 22 inches from center to center, which allowed 18 ties per rail length of 33 feet. In a few cases it was necessary to insert extra ties when the ties averaged less than 7 inches in width; also in filling in part of a rail length near the crossing, bridge, and switch. More than half of the roadbed is filled, which fact, together with the quality of the gravel, gives excellent drainage.

The test was arranged primarily to determine the durability of green, seasoned, and treated timbers which were cut at different seasons of the year. At the same time it will be possible to compare the effect of three forms of tie plates in reducing mechanical abrasion. In view of the diversified opinions as to the merits of each plate, this phase of the test will be carefully observed from year to year.

The screw spikes, 5,276 in number, and flat plates used in this test are similar to those used in the Maywood track, and were placed in the track as in the former instance.

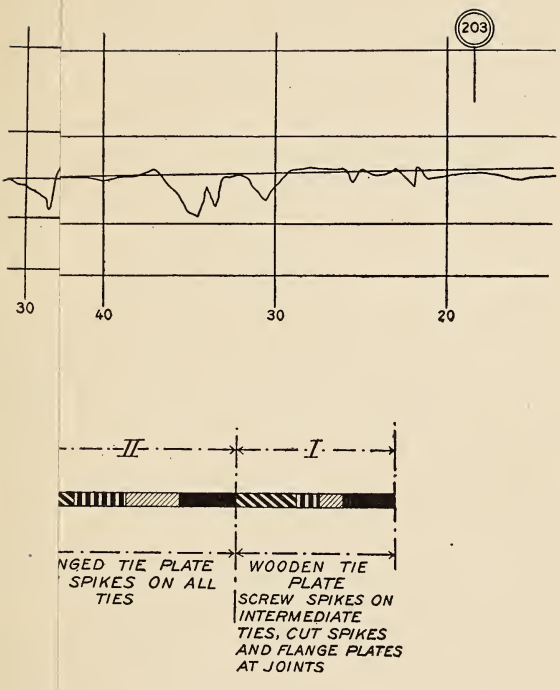
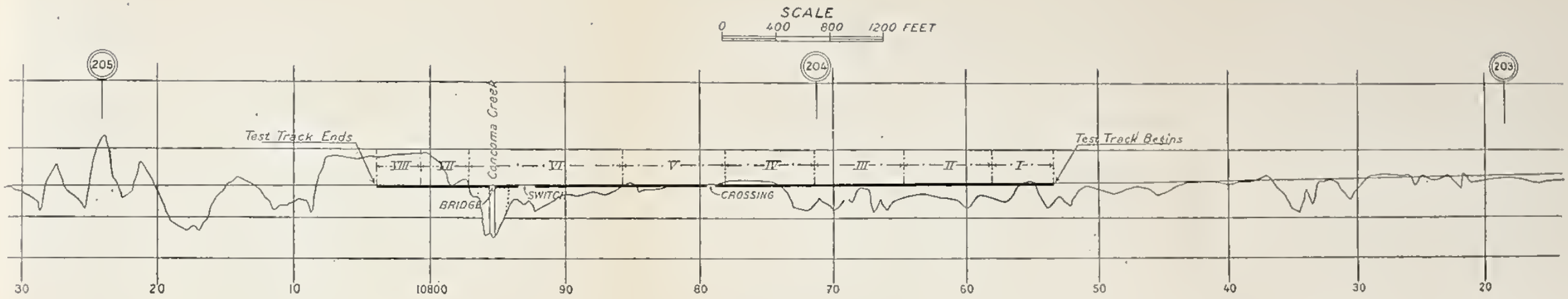


FIG. 3.—3,203 feet west of milepost 204. Series I laid with 72-pound



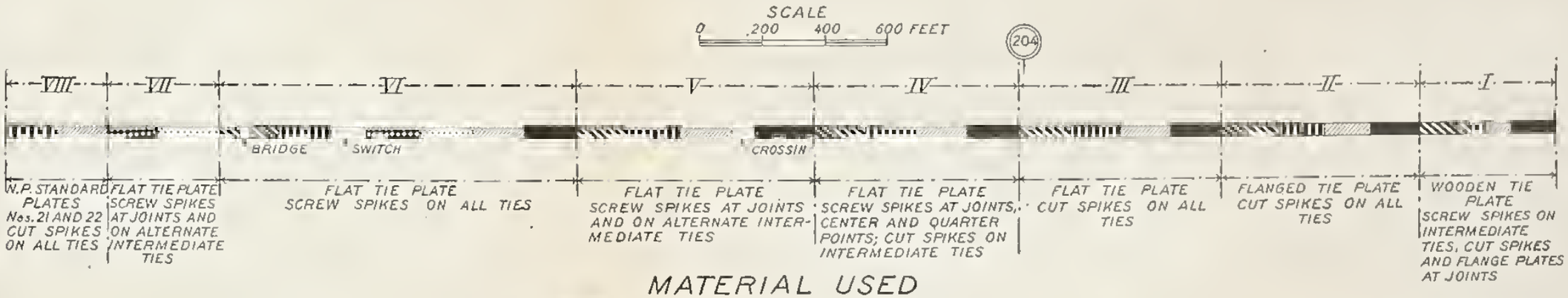


FIG. 3.—Northern Pacific Railway test track, 2 miles west of Plains, Mont., on main line, Rocky Mountain Division. Test track begins 3,461 feet west of milepost 203 and extends to 3,203 feet west of milepost 204. Series I laid with 72-pound steel; remainder of track laid with 85-pound steel.

SCHEME OF TESTS.

The 2,650 ties used in the test track were divided into eight series, varying from four to six logs in each series.

The object of dividing the ties in this test into series and lots, as represented in the following plan, was to compare the different materials under varying conditions. Series 1 is an independent test to determine the possibility of the adoption of wooden plates in conjunction with screw spikes. Series 2, 3, and 8 were of similar timbers under corresponding conditions, the only difference being in the form of the tie plates. Series 4, 5, 6, and 7 contain similar ties and represent the varying arrangements under which screw spikes may be employed. Thus the number of screw spikes per rail length increases as the series progress, reaches a maximum in series 6, and then diminishes in series 7.

Plan of test track, Northern Pacific Railway near Plains, Mont.

SERIES 1.—TOTAL, 250 TIES.[a]

Flanged plates and common spikes at rail joints; wooden plates and screw spikes (6 to the tie) on intermediate ties; 72-pound rail, joints opposite; total length 16 rails, 466 feet, contains 3 short rails (one 24, two 26 feet), regular length 30 feet.

Lot No.	Number of ties.	Kind of timber.	Tie Nos.
1	95	Green Douglas fir ties	1 to 95
2	32	Seasoned Douglas fir ties	96 to 127
3	27	Seasoned tamarack ties	128 to 154
4	96	Green tamarack ties	155 to 250

SERIES 2.—TOTAL, 365 TIES.

Flanged plates and common spikes; beginning with this series all track is laid with new 85-pound rail; joints alternate or "broken;" length of rail 33 feet; total length 20 rails, or 660 feet.

Lot No.	Number of ties.	Kind of timber.	Tie Nos.
1	94	Green Douglas fir ties	251 to 344
2	90	Seasoned Douglas fir ties	345 to 434
3	90	Seasoned tamarack ties	435 to 524
4	91	Green tamarack ties	525 to 615

SERIES 3.—TOTAL, 361 TIES.

Flat plates and common spikes; total length 20 rails, or 660 feet; extends to within 33 feet of mile post 204.

Lot No.	Number of ties.	Kind of timber.	Tie Nos.
1	91	Green Douglas fir ties	616 to 706
2	90	Seasoned Douglas fir ties	707 to 796
3	90	Seasoned tamarack ties	797 to 886
4	90	Green tamarack ties	887 to 976

[a] These ties average somewhat smaller than those in the other series.

Plan of test track, Northern Pacific Railway near Plains, Mont.—Continued.

SERIES 4.—TOTAL, 363 TIES.

Flat plates; screw spikes at joints, centers, and quarters, common spikes in other ties; 120 ties with screw spikes; 243 ties with common spikes.

Lot No.	Number of ties.	Kind of timber.	Tie Nos.
1	92	Green Douglas fir ties	977 to 1,068
2	90	Seasoned Douglas fir ties	1,069 to 1,158
3	90	Seasoned tamarack ties	1,159 to 1,248
4	91	Green tamarack ties	1,249 to 1,339

SERIES 5.—TOTAL, 379 TIES.

Screw spikes at joints and on alternate intermediate ties; flat plates; total length 23 rails, 759 feet east of crossing 4½ rails; crossing and two cattle guards 2¼ rails (nearly) omitted from test; 208 ties with screw spikes; 171 with common spikes.

Lot No.	Number of ties.	Kind of timber.	Tie Nos.
1	108	Green Douglas fir ties	1,340 to 1,447
2	90	Seasoned Douglas fir ties	1,448 to 1,537
3	90	Seasoned tamarack ties	1,538 to 1,627
4	91	Green tamarack ties	1,628 to 1,718

SERIES 6.—TOTAL, 553 TIES.

Flat plates, screw spikes in all ties; east of switch 19½ rails, 1 tie; omitted for switch 2½ rails, 2 ties; between bridge and switch 9¼ rails; bridge 1 rail (nearly) west of bridge 1¾ rails; total length 34 rails, 1,122 feet.

Lot No.	Number of ties.	Kind of timber.	Tie Nos.
1	90	Green Douglas fir ties	1,719 to 1,808
2	90	Seasoned Douglas fir ties	1,809 to 1,898
3	90	Treated Douglas fir ties	1,899 to 1,988
4	101	Treated tamarack ties	1,989 to 2,089
5	90	Seasoned tamarack ties	2,090 to 2,179
6	92	Green tamarack ties	2,180 to 2,271

SERIES 7.—TOTAL, 199 TIES.

Flat plates. Screw spikes at joints and on alternate intermediate ties. (Same as series 5) 111 ties with screw spikes; 88 ties with common spikes. Total length 11 rails and 1 tie, 365 feet.

Lot No.	Number of ties.	Kind of timber.	Tie Nos.
1	107	Treated Douglas fir ties	2,272 to 2,378
2	92	Treated tamarack ties	2,379 to 2,470

SERIES 8.—TOTAL, 180 TIES.

Combination of flat and flanged plates. Common spikes. Total length 10 rails, 330 feet.

Lot No.	Number of ties.	Kind of timber.	Tie Nos.
1	89	Seasoned Douglas fir ties	2,471 to 2,559
2	91	Seasoned tamarack ties	2,560 to 2,650

NOTE.—Ties marked consecutively from east to west with copper burrs placed 6 inches from rail base inside of left-hand rail going west.

Approved:

JAMES WILSON, *Secretary.*

WASHINGTON, D. C., *April 11, 1908.*

[Cir. 146]

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